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ESTIMATE OF ELECTRIC ENERGY REQUIREMENT WITH DUAL I SYSTEM

Report No 82-545-K

M.H. Tam
Mathematician
Reliability and Statistics Section
Operations Research Department

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ABSTRACT

A model for estimating the electric energy needed by an average home using a plenum heater is presented. Specifically, the cases of 50% and 100% displacement of oil by the plenum heater are discussed. Given the hourly temperatures of a day, a daily load curve is produced. This curve is used to compare plenum heater contribution to heating on a warm and a cold day. In addition, by accumulating the electricity required over a one-year period, an estimate of the annual electric energy requirement is derived.

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To Mr. F.J. Kee
Director of Research

ESTIMATE OF ELECTRIC ENERGY REQUIREMENT WITH DUAL I SYSTEM

1. INTRODUCTION

The rising cost and the uncertainty in supply of fossil fuels prompted research into alternative methods of home heating. As a result, the concept of dual heating systems evolved. In this setup, electricity is used to satisfy base heating load requirements while a fossil fuel supplies the energy necessary to meet extreme cold temperature demands. Two advantages of using a dual heating system are:

1. By adjusting the heater size, displacements from 50% to 100% of total oil usage can be achieved.

2. Oil, rather than electricity, is used during peak demand periods. This prevents overloading the power system at times when it is already highly stressed.

The Dual I system where at low temperatures the plenum heater and the oil furnace alternate under the control of a two-stage thermostat, is an example of a dual heating system. In this report, only the Dual I will be considered.

In order to make cost and efficiency comparisons between the Dual I heating system and other heating systems, the electric load demand curve of the average home under each system must be estimated. This report presents a model for estimating the load of a plenum heater assuming 50% and 100% displacement of oil. This work, requested by the Rates and Market Research Division on behalf of the Ministry of State for Science and Technology, is an extension of previous work/1/ where plenum heater size tables were produced for the above levels of oil displacement.

To evaluate the validity of the model, the following questions are examined.

(i) Do the magnitudes of the loads as well as the shape of the load curve agree with empirical expectation?

(ii) How accurate are the estimated loads?

2. DESCRIPTION OF THE DATA

The sample consisted of 19 homes from Southern Ontario which were equipped with plenum heaters. The heater sizes ranged from 4.9 kW to 18 kW with an average value of 8.3 kW. For each home, the electric heating loads in kW and hourly outdoor temperatures in degrees Celsius were available from October 1980 to May 1981. Further information on these homes can be found in /1/.

3. DEFINITION OF THE MODEL

The objective was to estimate the plenum heater load curve of the average home. The approach consisted of two steps. The first was to construct the load curve of a single home and the second, to average over all homes in the study. In the following, the case of 50% displacement of oil is discussed first followed by the 100% scenario.

3.1 50% Displacement of Oil

An example of the data collected from one home is shown in Figure 1. The darkened dots are the average values of the electric heating loads at each temperature. The temperature at which the maximum averaged kilowatt value occurs is called the changeover point (T_C). The operation of the plenum heater is unaffected by the oil furnace for temperatures greater than T_C. However, temperatures less than T_C are sufficiently cold so that the plenum heater cannot fully meet the heating demand of the home. In this temperature region, heating responsibility cycles back and forth between the plenum heater and the oil furnace under the control of a two-stage thermostat. The cycling process is illustrated in Figure 2. As the indoor temperature drops, the plenum heater is switched on to maintain the temperature at the first stage. However, when the temperature continues to drop, the plenum heater is turned off and the oil furnace is used to bring the temperature in the home back up to the first stage.

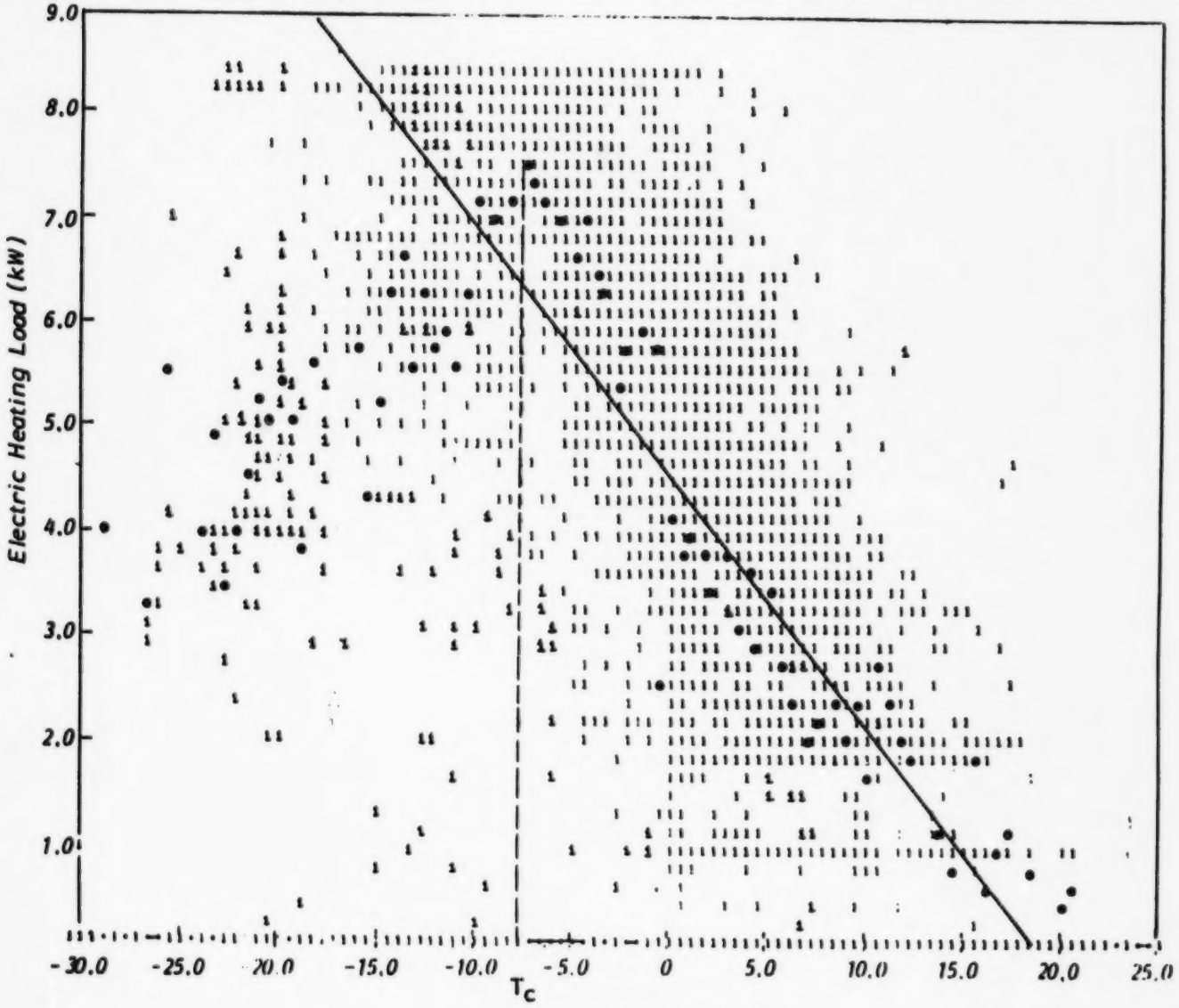


FIGURE 1

EXAMPLE OF DATA FROM ONE HOME

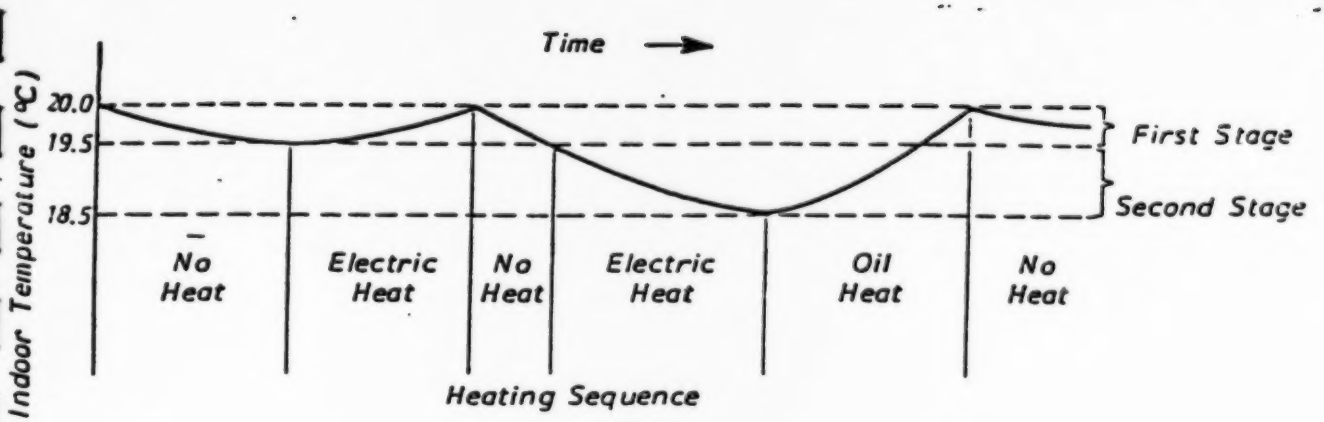


FIGURE 2

CYCLING BETWEEN THE PLENUM HEATER
AND THE OIL FURNACE

The load curve was estimated by the following method. The temperature was divided into appropriate subintervals and the loads were averaged within each of these. A downward sloping line called the electric heating system load curve (HSL) was fitted between the averaged loads and the corresponding temperatures which were greater than T_c (Figure 1). For temperatures in this region, the estimates of electric load demand can be simply read from the straight line.

Load estimation for temperatures less than T_c was not as straightforward. Plenum heater operation here was affected by the oil furnace size, the heater size, degree of home insulation, etc. Figure 3 illustrates the shape of the theoretical load curve to the left of T_c and how it is shifted, for a given plenum heater size, as a function of the oil furnace size. A curve indicating the portion of total heating load attributable to the plenum heater at temperatures less than T_c was estimated by the following procedure:

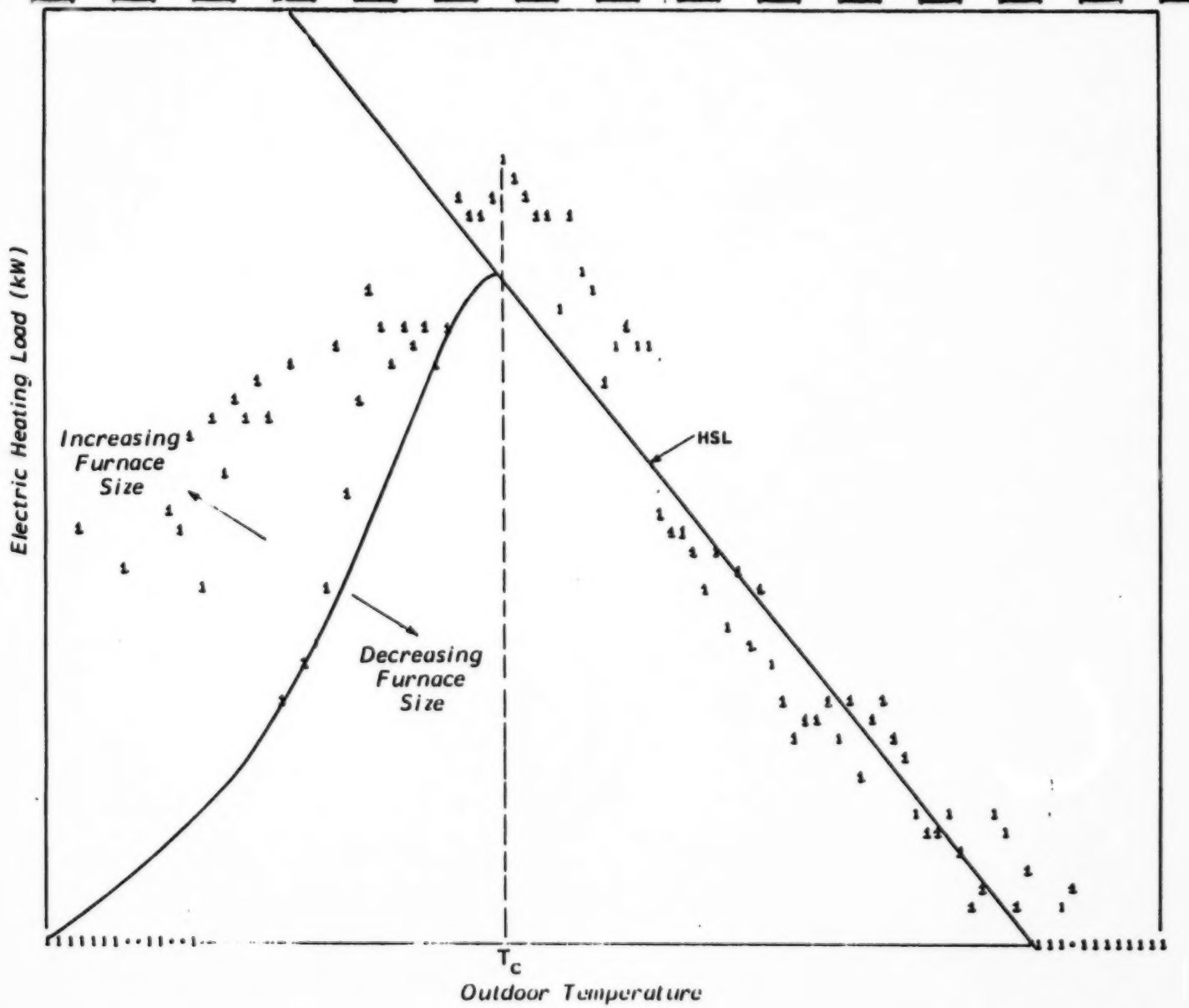


FIGURE 3

THEORETICAL ELECTRIC HEATING CURVE

(i) For each home, the temperatures less than T_c were grouped into subintervals of one degree. The ratio of the load kW_t at temperature t to the load kW_c at T_c,

$$R_t = kW_t/kW_c$$

provides the electric heating load at t as a proportion of the capacity of the plenum heater, ie, its load at T_c. (Figure 4).

(ii) The ratios from the different homes were averaged for each degree interval.

(iii) An equation of the form

$$y = e^{-(T_c-t)^a/b} \qquad (1)$$

was chosen to describe the average electric load curve for $t < T_c$, and was fitted by the method of least squares to the averaged ratios to obtain estimates of a and b.

The proportion of heating expected of the plenum heater was obtained from equation (1). This proportion was further multiplied by the heater size of the home to get the estimated load.

3.2 100% Displacement of Oil

For 100% displacement of oil, the electric loads were estimated by the HSL down to the temperature where the load reaches the capacity of the heater. Below that temperature, the electric loads were set equal to the capacity of the heater.

3.3 Load Estimation Procedure

The previous two sections describe the motivations and techniques involved in estimating the electric load under 50% and 100% displacement of oil. This section summarizes the method to follow for each of these cases.

(1) 50% Displacement of Oil:

(i) The historical oil consumption of each home was used to find a recommended heater size from the 50% heater size table in /1/.

(ii) The size of the heater was used to determine the changeover point T_c from the electric heating system load curve of each home.

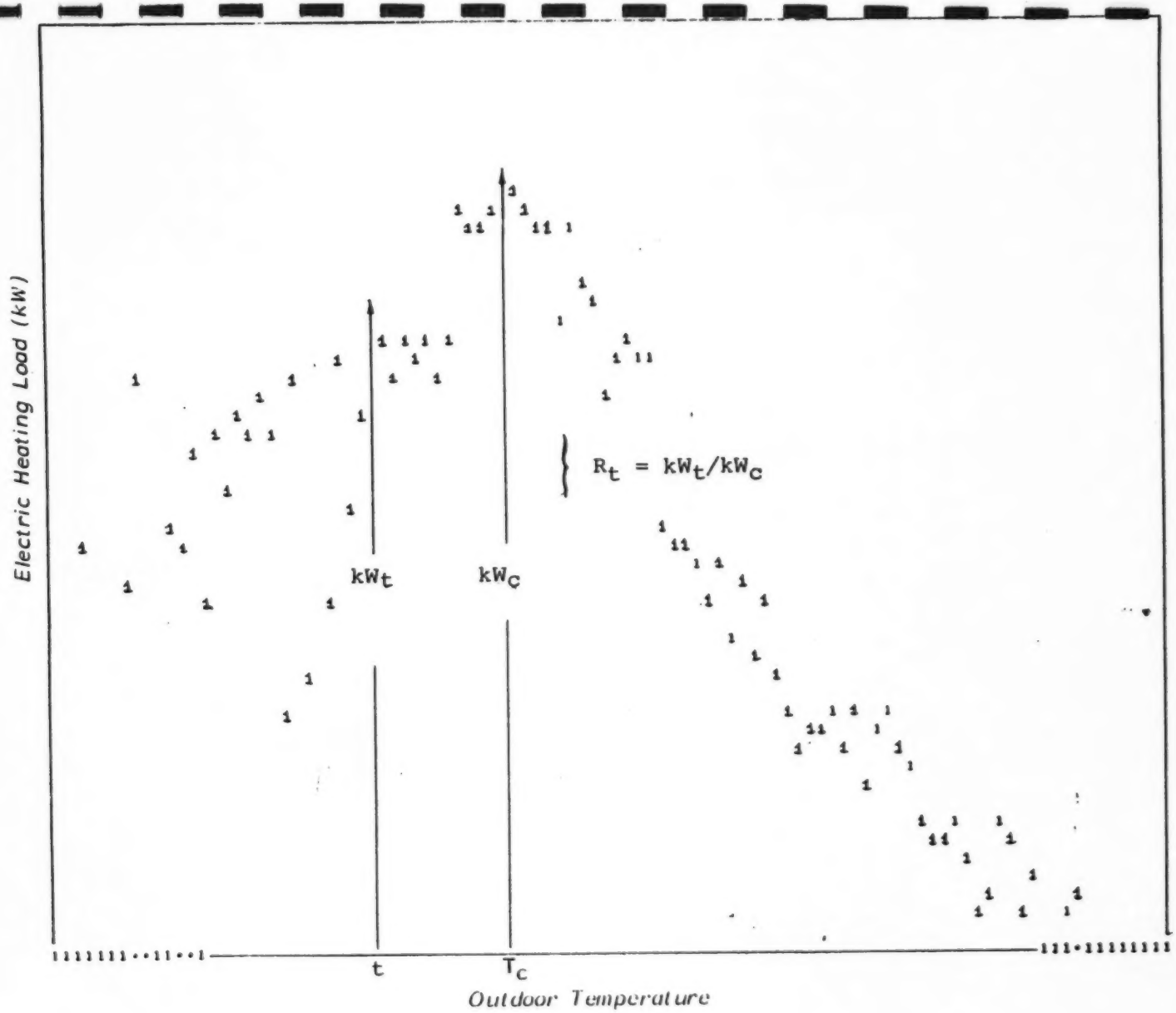


FIGURE 4

PROCEDURE TO CONSTRUCT 50% ELECTRIC HEATING CURVE

(iii) The hourly temperatures of the day were classified by whether they were less than or greater than T_C.

(iv) Electric load was estimated by the electric heating system load for temperatures greater than T_C and by equation (1) for temperatures less than T_C.

(2) 100% Displacement of Oil:

(i) From the historical oil consumption of each home, a recommended heater size was found from the 100% heater size table in /1/.

(ii) Loads to the left of the point on the HSL curve determined by the heater size were assigned values equal to the capacity of the heater.

(iii) Electric load was estimated by the HSL curve as modified in (ii).

4. EVALUATION OF THE MODEL

4.1 Predicted Electric Heating Load Curves

Figures 5 and 6 are typical examples of the predicted electric load curves from a single home for the 50% case: Figure 5 illustrates a warm day. The load curve is valley shaped with the bottom of the valley stretching from noon to about six hours afterwards. Since the warmest period of the day occurs in this time span, the plenum heater is expected to be used to a smaller extent than, say, during the morning or the evening. By contrast, the points in Figure 6 represent a cold day. The electric load peaks in the afternoon, as heating for the other hours of the day is supplemented by the oil furnace due to colder temperatures.

4.2 Accuracy in Estimation

Actual and predicted load curves of the average home for two different warm days are shown in Figures A1 and A2 in the Appendix. Figures A3 and A4 represent two different cold days. The difference between the two curves is about a kilowatt in most cases. This can be explained by the following:

1. The actual average load curve incorporates a time lag factor in heating, ie, the plenum heater cooled down/warmed up several hours after the outdoor temperature has risen/dropped. The predictive model presented in this report assumes an instantaneous reaction to temperature.

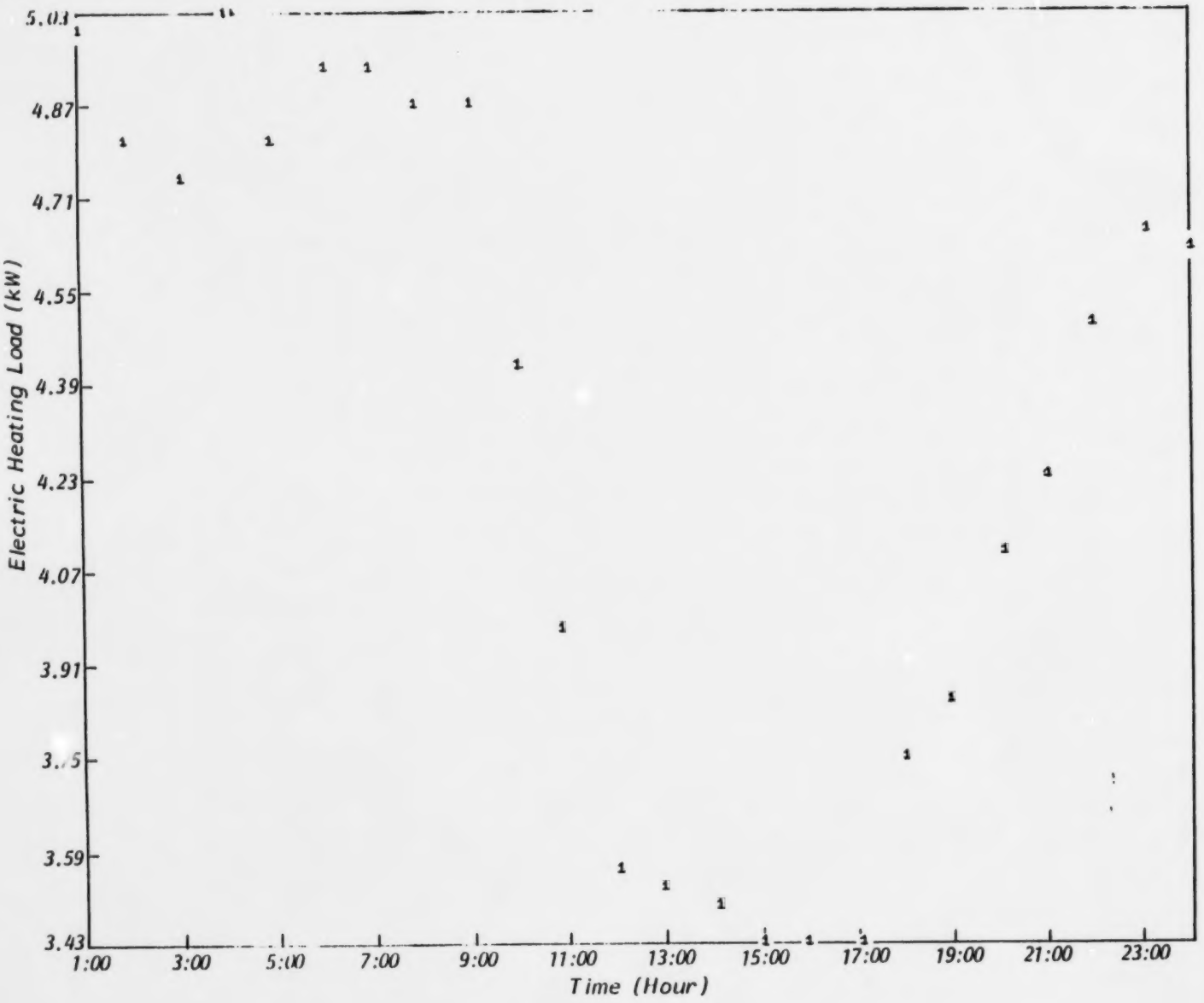


FIGURE 5

ELECTRIC HEATING CURVE
ON A WARM DAY

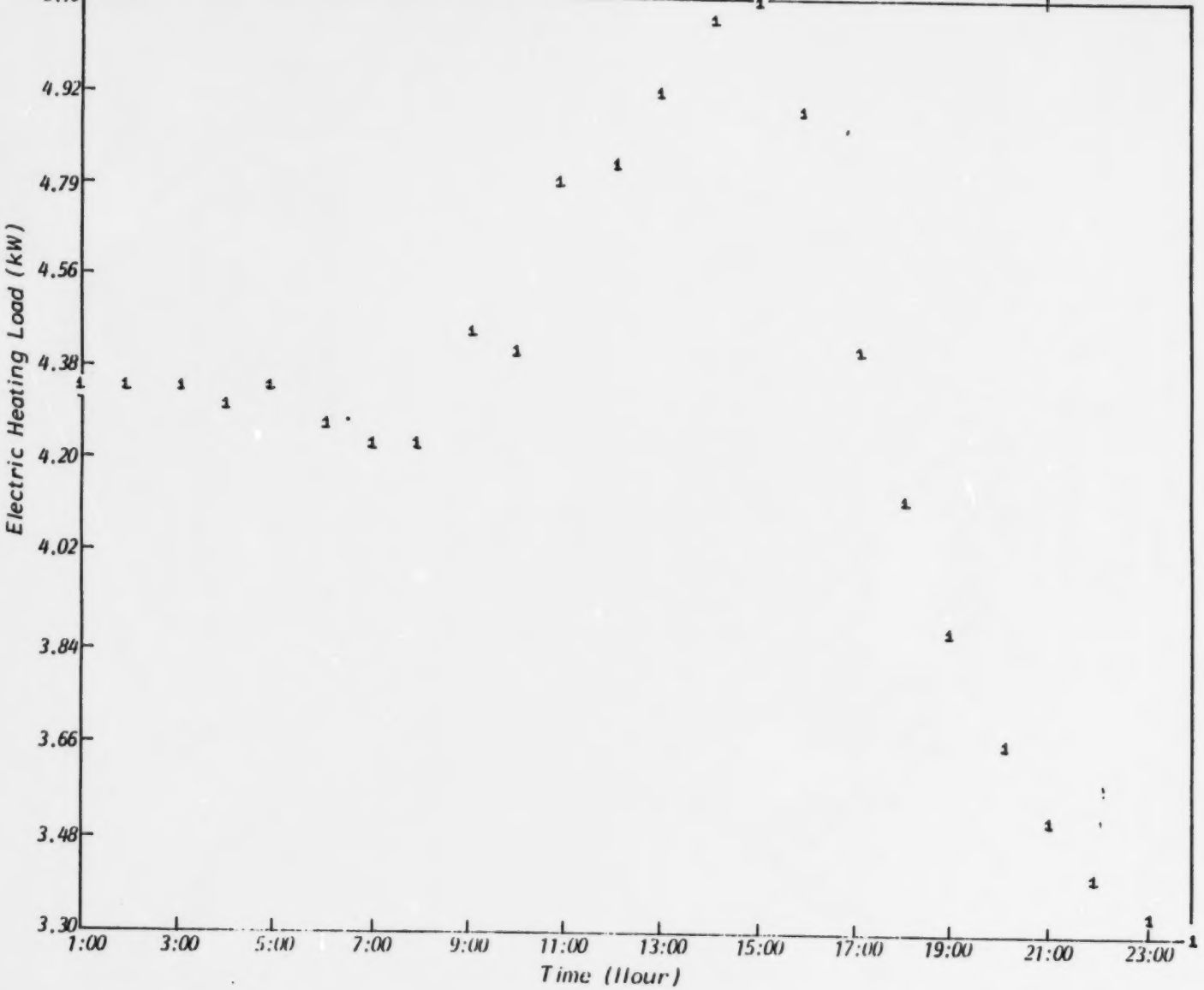


FIGURE 6

ELECTRIC HEATING CURVE
ON A COLD DAY

2. The electric heating system load curve of each home estimates the average electric load at each temperature. As a result, the predicted plenum heater load curve of the average home is the average of these averaged values. However, the actual load curve of the average home is the average of observations which are scattered around the individual HSL's.

5. RESULTS AND CONCLUSION

1. For 50% displacement of oil, Tables 1 to 4 in the Appendix show the total demand for electricity of an average home by season. The winter season consisted of September to March. The off-peak period was defined to be weekends, statutory holidays and 11:00 pm to 7:00 am on weekdays. Table 5 shows the breakdown of this total demand by hour and month and Table 6 is the average daily demand by hour and month. A similar set of tables was produced for 100% case (Tables 7 to 12).

2. The difference in the total amount of electric energy used between the 50% case (18 997.16 kWh) and the 100% case (21 724.56 kWh) is small. This can be attributed to the 50% heater size table in /1/. The recommended heater sizes are conservative for the following reasons.

   (i) Heater sizes were adjusted to conform with sizes available on the market.

   (ii) The heater sizes take into consideration the different control devices which may be used to operate the plenum heater. Different control devices may require different heater sizes to displace the same amount of oil.

3. Displacement is a function of temperature. For warmer days, the plenum heater is used almost exclusively for heating (Figure 7) while on colder days, the heating responsibility is shared between the plenum heater and the oil furnace (Figure 8).

4. The model employed in the study uses averages to predict electric heating loads and this approach has

some inherent limitations. Since the electric heating load of any one home depends on many factors in addition to the outdoor temperature, wide deviations from the average may occur in individual cases, and caution must be exercised when using the results in this report.

Approved:

for J.G. Cassan
Manager
Operations Research Department

Submitted:

M.H. Tam
Mathematician
Reliability & Statistics Section

MHT:rh:rv

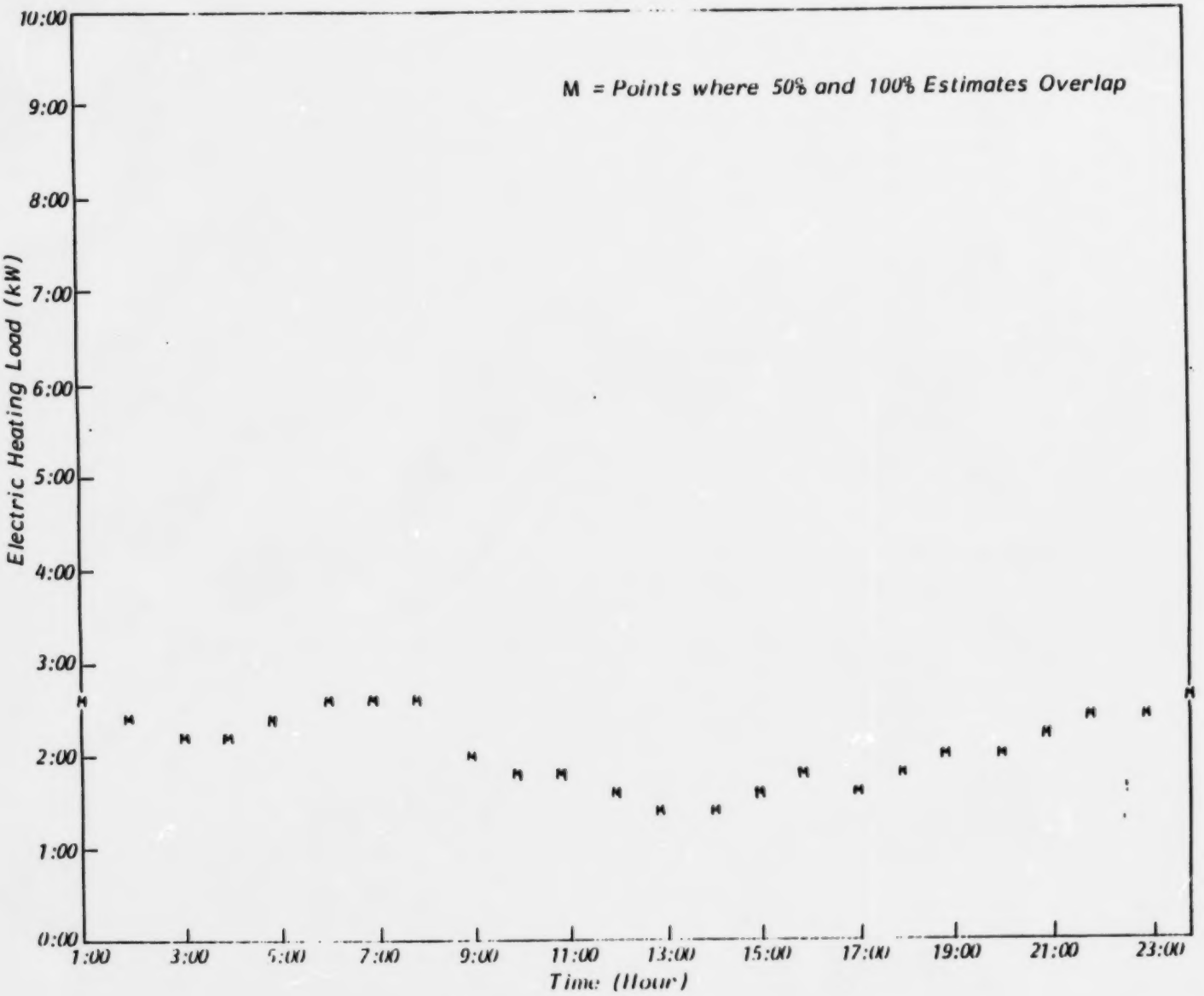


FIGURE 7

50% AND 100% ELECTRIC HEATING CURVE ON A WARM DAY

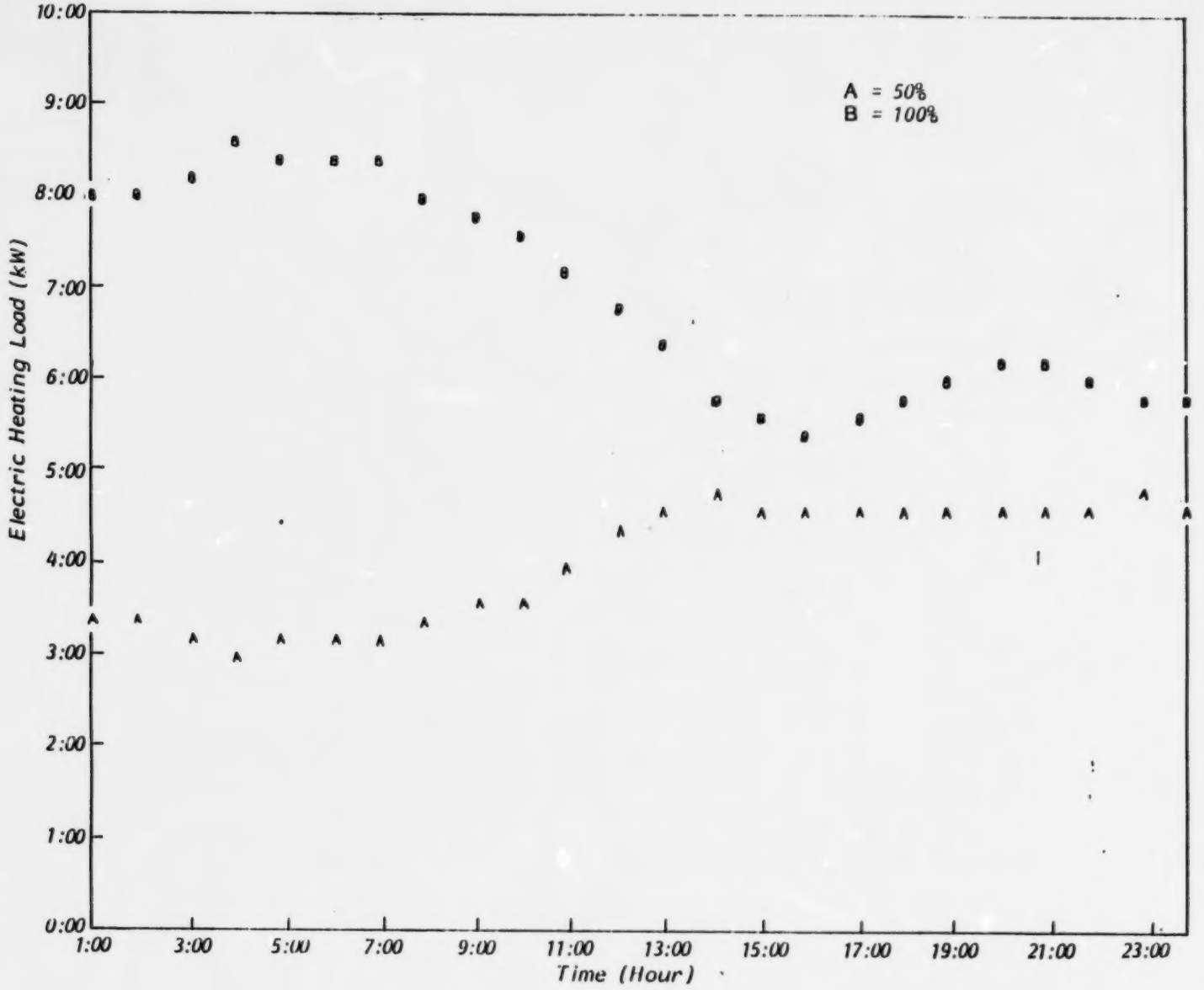
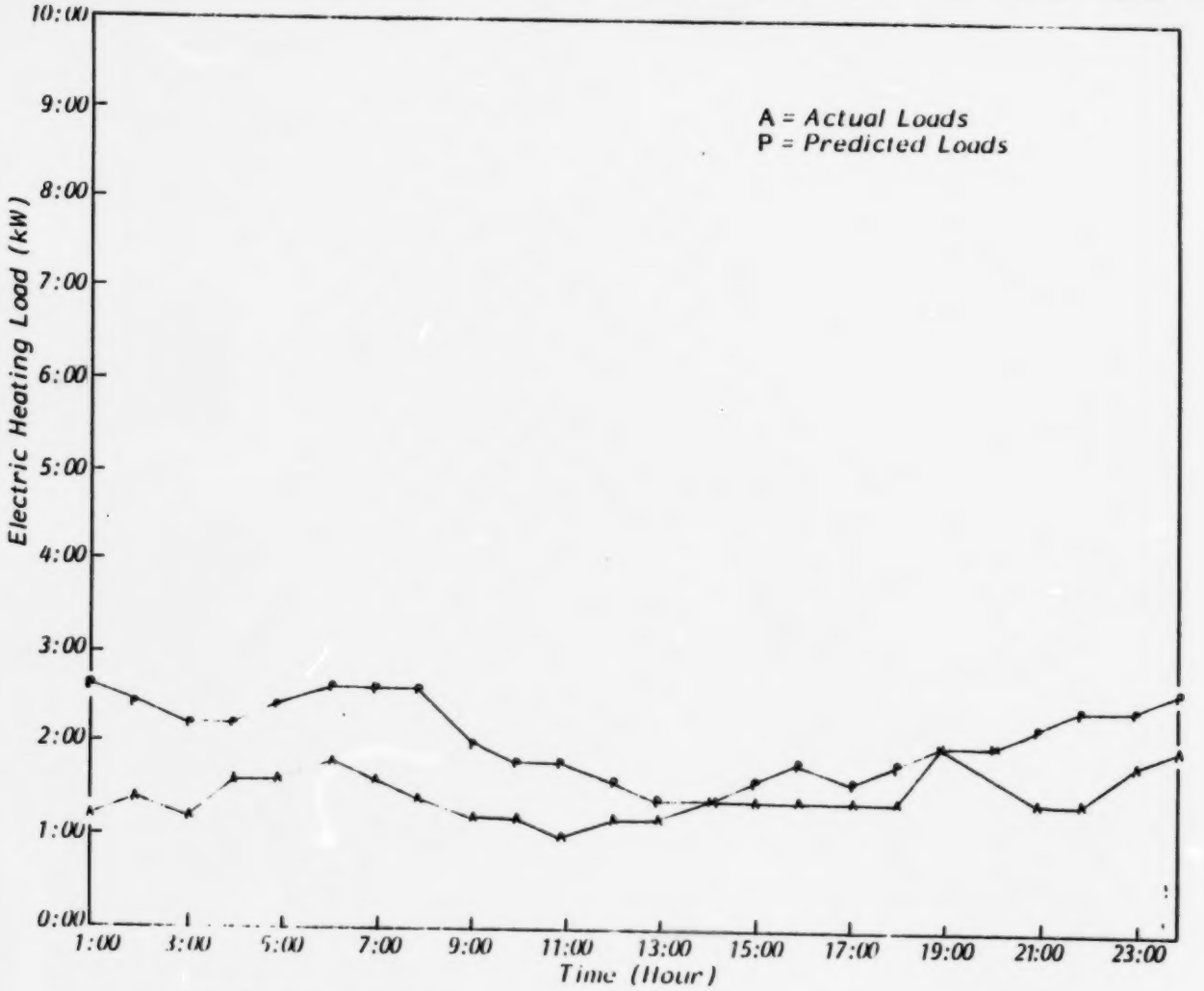


FIGURE 8

50% AND 100% ELECTRIC HEATING CURVE ON A COLD DAY

APPENDIX



The Temperatures are:

Hours 1-12	5.6	6.2	6.8	6.9	6.4	5.4	5.5	5.5	7.8	9.5	9.5	10.4
Hours 13-24	11.0	11.2	10.0	9.1	10.5	9.6	8.1	7.8	7.1	5.8	6.4	5.4

FIGURE A1

FIRST WARM DAY
ACTUAL AND PREDICTED ELECTRIC HEATING CURVE

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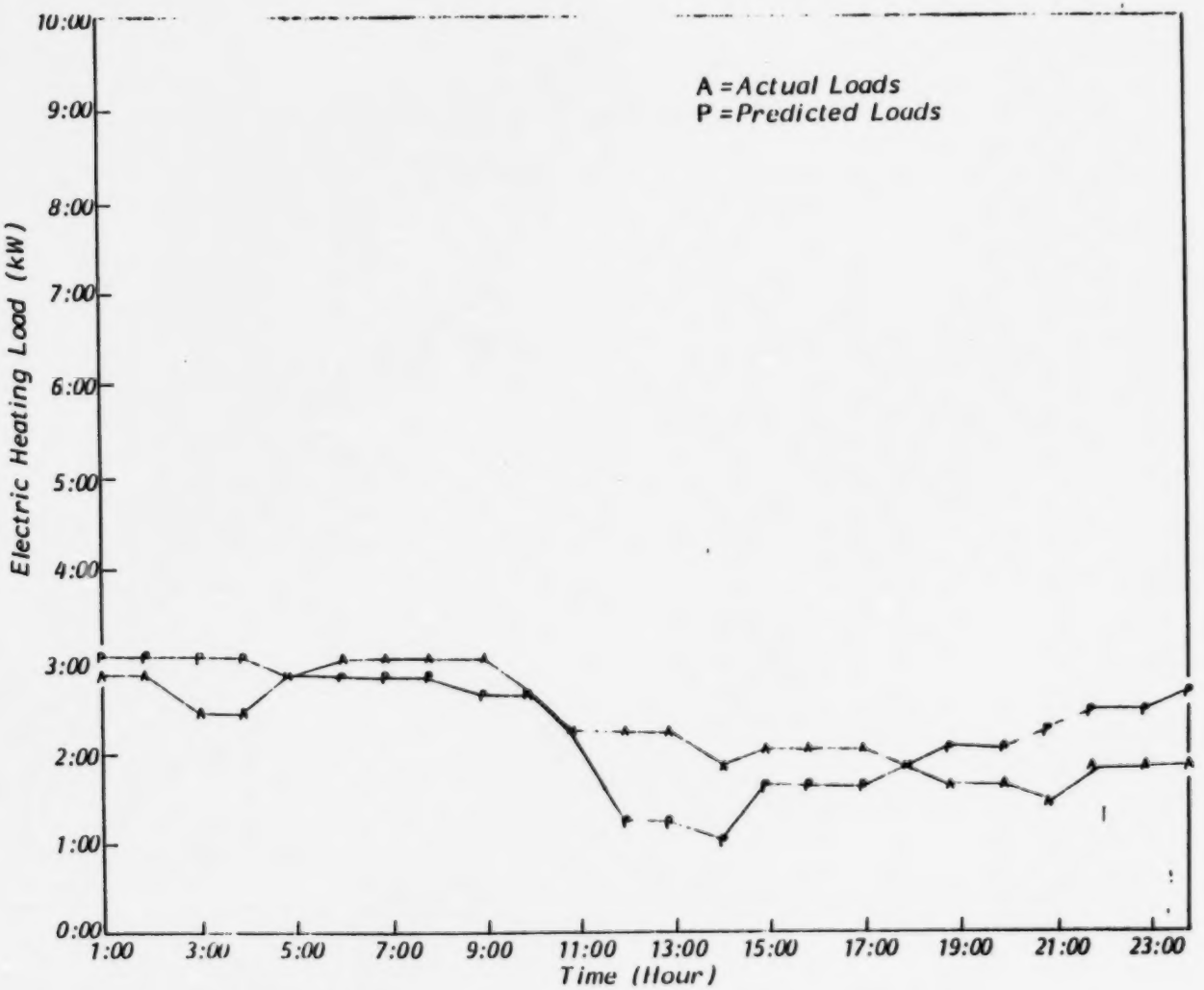
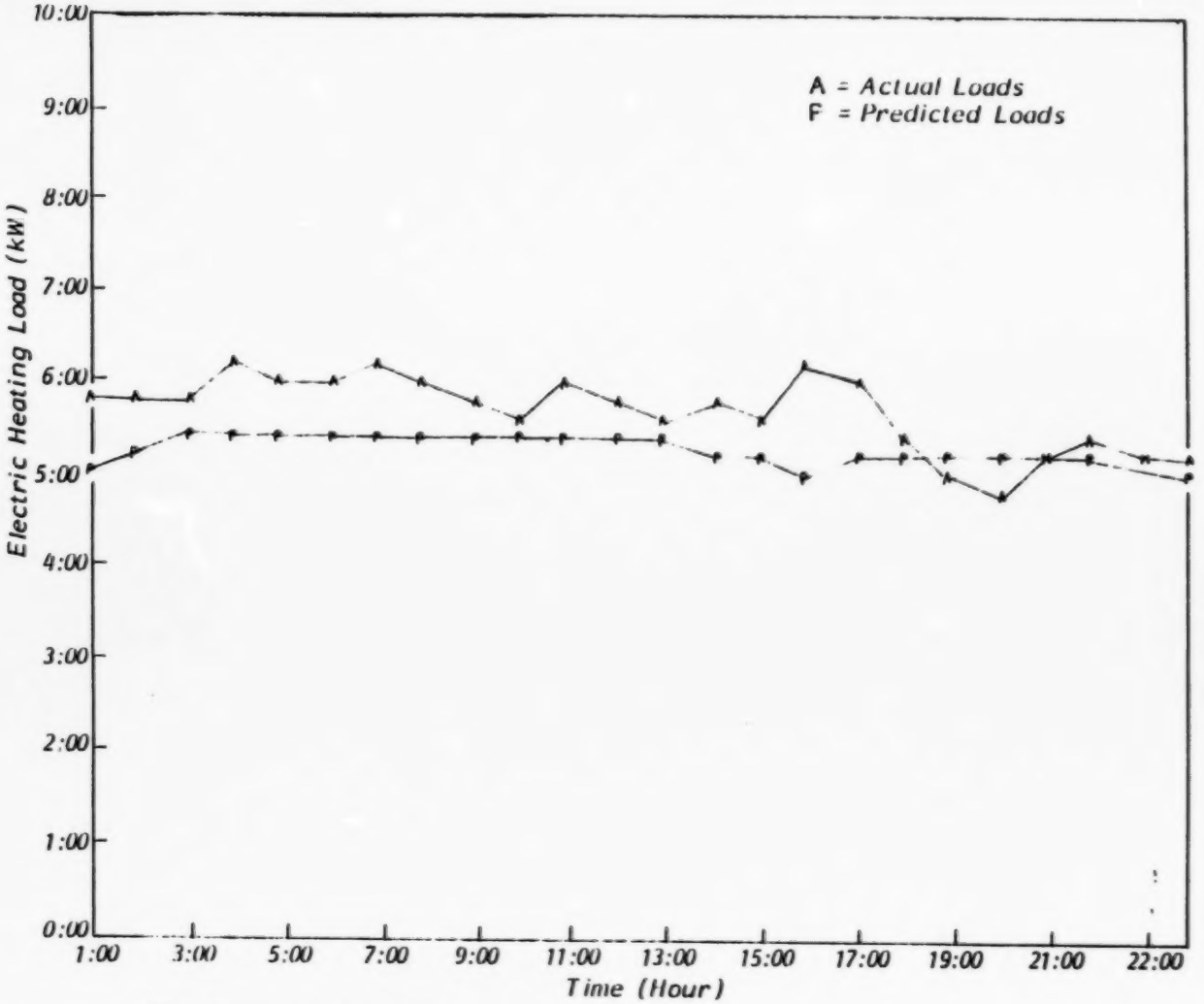


The Temperatures are:

Hours 1-12	3.0	3.1	3.2	3.5	4.0	4.3	4.5	4.5	5.0	5.5	7.6	12.6
Hours 13-24	12.8	13.4	10.1	10.5	10.1	9.5	8.5	7.8	7.6	6.2	6.0	5.1

FIGURE A2

SECOND WARM DAY
ACTUAL AND PREDICTED HEATING CURVE

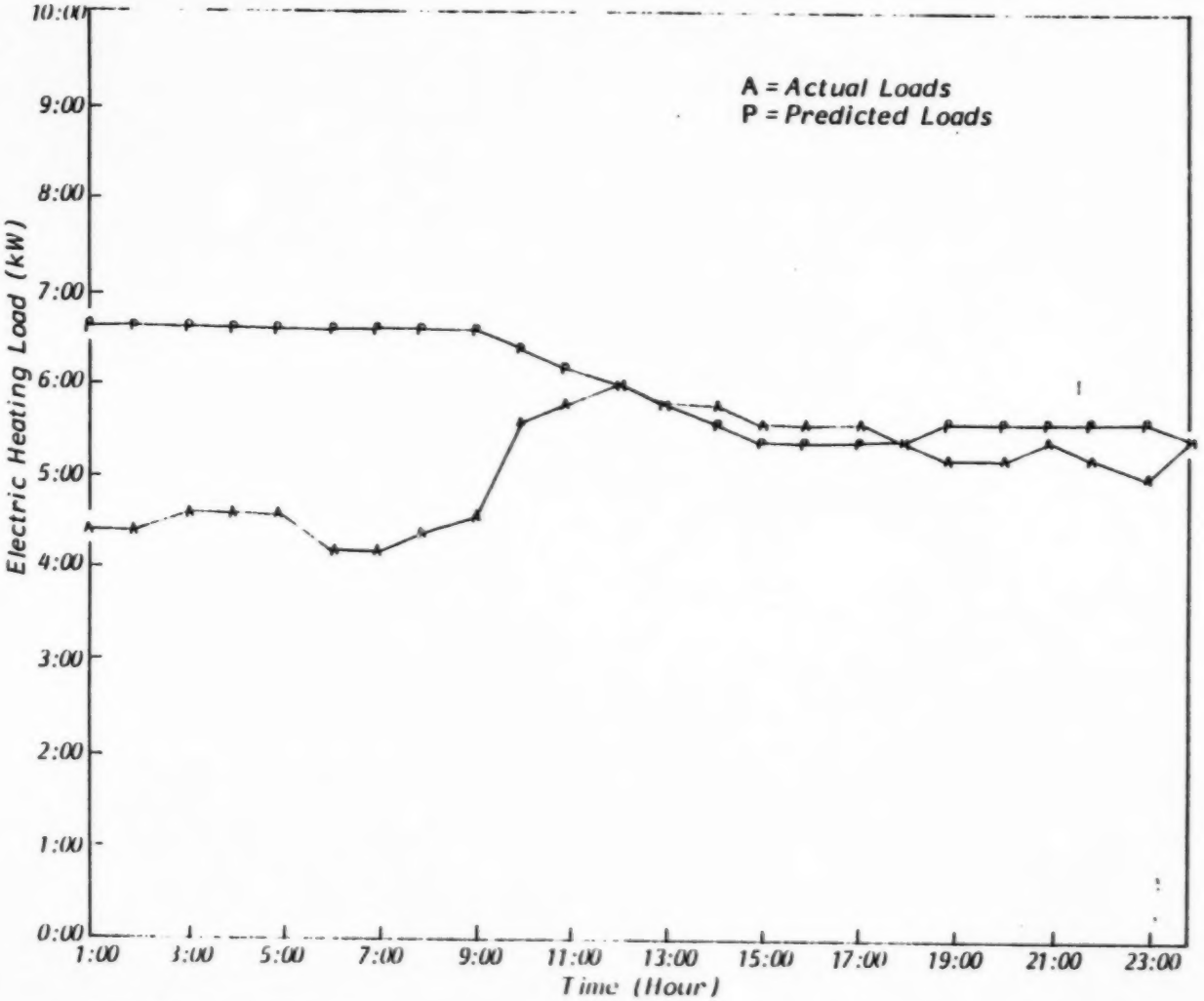


The temperatures are:

Hours 1–12	-7.2	-7.5	-8.4	-8.6	-8.4	-8.9	-8.8	-8.9	-9.0	-9.0	-9.0	-8.6
Hours 13–24	-8.3	-7.4	-7.3	-7.1	-7.3	-7.6	-7.6	-7.6	-7.6	-7.6	-7.4	-7.2

FIGURE A3

FIRST COLD DAY
ACTUAL AND PREDICTED ELECTRIC HEATING CURVE



The Temperatures are:

Hours 1–12	-21.2	21.7	21.9	-22.0	22.0	-21.6	21.3	-20.2	-19.4	-16.2	-14.8	-13.0
Hours 13–24	-11.5	10.0	9.0	8.5	-8.6	9.2	10.0	-10.3	-10.5	-10.3	-9.8	-9.0

FIGURE A4

SECOND COLD DAY
ACTUAL AND PREDICTED ELECTRIC HEATING CURVE

TABLE 1

HEATING LOAD FOR THE AVERAGE HOME
Winter Season
On-Peak
50% Oil Displacement

HOUR	KWH	% OF TOTAL SEASONAL KWH	AVERAGE KW
1			
2			
3			
4			
5			
6			
7			
8	507.52	3.043	3.43
9	491.93	2.950	3.32
10	471.94	2.830	3.19
11	456.15	2.735	3.08
12	445.30	2.670	3.01
13	436.42	2.617	2.95
14	435.19	2.609	2.94
15	435.83	2.613	2.94
16	442.94	2.656	2.99
17	455.25	2.730	3.08
18	471.64	2.828	3.19
19	482.17	2.891	3.26
20	493.22	2.957	3.33
21	497.71	2.984	3.36
22	503.12	3.017	3.40
23	505.69	3.032	3.42
24	508.91	3.051	3.44
SUM	8040.94	48.213	
AVG			2.26

TABLE 2

HEATING LOAD FOR THE AVERAGE HOME
Winter Season
Off-Peak
50% Oil Displacement

HOUR	KWH	% OF TOTAL SEASONAL KWH	AVERAGE KW
1	731.70	4.387	3.45
2	733.80	4.400	3.46
3	735.82	4.412	3.47
4	740.73	4.441	3.49
5	742.59	4.453	3.50
6	743.69	4.459	3.51
7	736.27	4.415	3.47
8	210.17	1.260	3.28
9	204.91	1.229	3.20
10	199.49	1.196	3.12
11	197.08	1.182	3.08
12	194.97	1.169	3.05
13	192.82	1.156	3.01
14	190.75	1.144	2.98
15	191.41	1.148	2.99
16	193.09	1.158	3.02
17	198.46	1.190	3.10
18	203.94	1.223	3.19
19	208.01	1.247	3.25
20	213.02	1.277	3.33
21	215.46	1.292	3.37
22	218.79	1.312	3.42
23	219.28	1.315	3.43
24	220.81	1.324	3.45
SUM	8637.04	51.787	
AVG			3.28
TOTAL SEASONAL KWH		16677.97	

TABLE 3

HEATING LOAD FOR THE AVERAGE HOME
Summer Season
On-Peak
50% Oil Displacement

HOUR	KWH	% OF TOTAL SEASONAL KWH	AVERAGE KW
1			
2			
3			
4			
5			
6			
7			
8	59.44	2.563	.57
9	50.68	2.185	.49
10	44.89	1.935	.43
11	41.20	1.776	.40
12	37.51	1.617	.36
13	35.36	1.524	.34
14	35.20	1.518	.34
15	34.78	1.500	.33
16	35.47	1.529	.34
17	37.78	1.629	.36
18	41.93	1.808	.40
19	47.75	2.059	.46
20	55.53	2.394	.53
21	63.29	2.729	.61
22	70.54	3.041	.68
23	74.29	3.203	.71
24	78.17	3.371	.75
SUM	843.80	36.384	
AVG			.34

TABLE 4

HEATING LOAD FOR THE AVERAGE HOME
Summer Season
Off-Peak
50% Oil Displacement

HOUR	KWH	% OF TOTAL SEASONAL KWH	AVERAGE KW
1	130.93	5.645	.86
2	135.17	5.828	.88
3	139.25	6.004	.91
4	141.20	6.088	.92
5	146.44	6.314	.96
6	140.64	6.064	.92
7	122.06	5.263	.80
8	41.42	1.786	.85
9	35.36	1.525	.72
10	29.53	1.273	.60
11	26.94	1.162	.55
12	24.63	1.062	.50
13	22.77	.982	.46
14	22.39	.966	.46
15	21.02	.907	.43
16	21.40	.923	.44
17	21.67	.934	.44
18	24.44	1.054	.50
19	29.13	1.256	.59
20	34.01	1.466	.69
21	37.69	1.625	.77
22	40.00	1.725	.82
23	42.96	1.852	.88
24	44.33	1.911	.90
SUM	1475.38	63.616	
AVG			.70
TOTAL SEASONAL KWH		2319.18	

TABLE 5

TOTAL ELECTRIC HEATING LOAD FOR THE AVERAGE HOME
50% OIL DISPLACEMENT

TOTAL KWH BY HOUR AND MONTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM
1	134.67	121.94	122.78	81.83	49.10	.00	.00	.00	28.11	77.62	113.36	133.23	862.63
2	133.54	122.46	123.25	83.41	51.77	.00	.00	.00	29.54	78.57	113.55	132.90	868.98
3	132.90	121.62	123.83	85.22	54.03	.00	.00	.00	30.87	79.05	115.20	132.35	875.07
4	132.52	121.18	125.23	86.15	55.05	.00	.00	.00	32.17	80.79	115.50	133.43	881.93
5	132.33	120.72	125.60	86.98	59.46	.00	.00	.00	33.45	81.53	115.62	133.28	889.03
6	132.23	120.46	125.85	86.70	53.94	.00	.00	.00	35.27	82.74	116.46	133.47	884.33
7	132.41	120.07	123.98	82.66	39.40	.00	.00	.00	30.12	81.31	116.50	131.87	858.33
8	132.52	119.89	122.35	72.51	28.35	.00	.00	.00	23.82	72.75	115.24	131.11	818.55
9	133.80	121.03	120.68	63.47	22.58	.00	.00	.00	18.81	63.89	108.02	130.61	782.88
10	134.85	121.37	115.85	56.96	17.47	.00	.00	.00	14.49	54.46	100.40	129.97	745.85
11	135.91	121.30	111.85	53.17	14.97	.00	.00	.00	11.89	47.59	94.96	129.80	721.37
12	136.97	119.61	107.70	49.56	12.58	.00	.00	.00	10.96	44.78	92.51	128.73	702.42
13	136.47	118.22	104.61	46.50	11.62	.00	.00	.00	9.87	40.74	91.63	127.70	687.36
14	136.91	117.65	103.29	45.00	12.60	.00	.00	.00	9.71	38.74	92.43	127.21	683.54
15	136.99	117.88	101.97	44.10	11.70	.00	.00	.00	9.06	40.60	93.35	127.40	683.04
16	137.84	118.73	101.83	44.38	12.54	.00	.00	.00	10.20	43.81	95.78	128.65	692.89
17	138.48	119.81	104.29	45.74	13.71	.00	.00	.00	11.06	50.48	99.54	130.07	713.16
18	138.62	121.81	108.99	50.08	16.28	.00	.00	.00	14.41	57.99	103.48	130.27	741.94
19	138.87	122.53	112.13	56.39	20.49	.00	.00	.00	18.35	62.59	105.86	129.83	767.06
20	138.64	122.90	116.14	65.25	26.31	.00	.00	.00	22.79	67.33	108.05	130.38	795.77
21	137.98	122.95	118.56	67.77	33.21	.00	.00	.00	24.32	69.08	109.58	130.69	814.15
22	137.28	123.30	119.52	71.37	39.17	.00	.00	.00	27.79	72.46	110.23	131.34	832.45
23	136.28	122.44	120.58	74.56	42.69	.00	.00	.00	28.05	74.18	111.40	132.13	842.22
24	135.40	122.36	121.65	76.83	45.67	.00	.00	.00	28.75	75.77	112.78	133.11	852.22
SUM	3253.39	2902.22	2781.76	1574.50	744.68	.00	.00	.00	511.76	1538.06	2551.36	3139.44	18997.16

TABLE 6

AVERAGE DAILY ELECTRIC HEATING LOAD FOR THE AVERAGE HOME
50% OIL DISPLACEMENT

AVERAGE KWH BY HOUR AND MONTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG
1	4.34	4.36	3.96	2.71	1.58	.00	.01	.01	.94	2.50	3.78	4.30	2.37
2	4.31	4.37	3.98	2.78	1.67	.00	.00	.01	.98	2.53	3.78	4.29	2.39
3	4.29	4.34	3.99	2.84	1.74	.00	.00	.00	1.03	2.55	3.84	4.27	2.41
4	4.27	4.33	4.04	2.87	1.78	.00	.00	.00	1.07	2.61	3.85	4.30	2.43
5	4.27	4.31	4.05	2.90	1.82	.00	.00	.00	1.12	2.63	3.85	4.30	2.45
6	4.27	4.30	4.03	2.89	1.74	.00	.00	.00	1.11	2.67	3.88	4.31	2.43
7	4.27	4.29	4.00	2.76	1.27	.00	.00	.00	1.00	2.62	3.88	4.25	2.36
8	4.27	4.28	3.95	2.42	.91	.00	.00	.00	.79	2.35	3.84	4.23	2.25
9	4.32	4.32	3.89	2.12	.73	.00	.00	.00	.63	2.06	3.60	4.21	2.16
10	4.35	4.33	3.74	1.90	.56	.00	.00	.00	.48	1.76	3.35	4.15	2.06
11	4.38	4.35	3.61	1.77	.48	.00	.00	.00	.40	1.54	3.16	4.19	1.99
12	4.39	4.37	3.47	1.65	.41	.00	.00	.00	.37	1.44	3.09	4.15	1.94
13	4.40	4.22	3.37	1.55	.37	.00	.00	.00	.33	1.31	3.06	4.12	1.90
14	4.42	4.20	3.33	1.51	.41	.00	.00	.01	.32	1.25	3.08	4.10	1.88
15	4.43	4.21	3.29	1.47	.38	.00	.00	.00	.30	1.31	3.11	4.11	1.88
16	4.45	4.24	3.28	1.48	.41	.00	.00	.00	.34	1.39	3.19	4.15	1.91
17	4.47	4.28	3.36	1.52	.44	.00	.00	.00	.37	1.63	3.32	4.20	1.97
18	4.47	4.35	3.52	1.67	.53	.00	.00	.01	.48	1.87	3.45	4.20	2.04
19	4.48	4.38	3.68	1.86	.46	.00	.00	.00	.61	2.02	3.53	4.19	2.11
20	4.47	4.39	3.75	2.11	.45	.00	.00	.00	.76	2.17	3.61	4.21	2.19
21	4.45	4.39	3.82	2.26	1.07	.00	.00	.00	.81	2.23	3.65	4.22	2.24
22	4.43	4.40	3.86	2.36	1.26	.00	.00	.00	.93	2.34	3.67	4.24	2.29
23	4.39	4.37	3.89	2.45	1.38	.00	.00	.00	.93	2.39	3.71	4.26	2.32
24	4.37	4.37	3.92	2.51	1.47	.00	.00	.00	.96	2.44	3.76	4.29	2.35
AVG	4.37	4.32	3.74	2.19	1.00	.00	.00	.00	.71	2.07	3.54	4.22	2.18

TABLE 7

HEATING LOAD FOR THE AVERAGE HOME
Winter Season
On-Peak
100% Oil Displacement

HOUR	KWH	% OF TOTAL SEASONAL KWH	AVERAGE KW
1			
2			
3			
4			
5			
6			
7			
8	608.28	3.138	4.11
9	579.20	2.988	3.91
10	545.26	2.813	3.68
11	515.77	2.661	3.48
12	496.05	2.559	3.35
13	481.72	2.485	3.25
14	477.60	2.464	3.23
15	476.91	2.460	3.22
16	486.54	2.510	3.29
17	505.00	2.605	3.41
18	527.99	2.724	3.57
19	543.14	2.802	3.67
20	560.37	2.891	3.79
21	569.47	2.938	3.85
22	577.86	2.981	3.90
23	582.80	3.006	3.94
24	590.64	3.047	3.99
SUM	9124.60	47.070	
AVG			2.57

TABLE 8

HEATING LOAD FOR THE AVERAGE HOME
Winter Season
Off-Peak
100% Oil Displacement

HOUR	KWH	% OF TOTAL SEASONAL KWH	AVERAGE KW
1	863.61	4.455	4.07
2	871.60	4.496	4.11
3	882.19	4.551	4.16
4	890.32	4.593	4.20
5	895.65	4.620	4.22
6	900.59	4.646	4.25
7	896.35	4.624	4.23
8	261.49	1.349	4.09
9	251.82	1.299	3.93
10	240.57	1.241	3.76
11	230.47	1.189	3.60
12	223.61	1.154	3.49
13	218.60	1.128	3.42
14	215.92	1.114	3.37
15	216.14	1.115	3.38
16	218.46	1.127	3.41
17	225.57	1.164	3.52
18	235.08	1.213	3.67
19	241.02	1.243	3.77
20	247.89	1.279	3.87
21	252.00	1.300	3.94
22	257.35	1.328	4.02
23	260.66	1.345	4.07
24	263.59	1.360	4.12
SUM	10260.56	52.930	
AVG			3.86
TOTAL SEASONAL KWH		19385.17	

TABLE 9

HEATING LOAD FOR THE AVERAGE HOME
Summer Season
On-Peak
100% Oil Displacement

HOUR	KWH	% OF TOTAL SEASONAL KWH	AVERAGE KW
1			
2			
3			
4			
5			
6			
7			
8	59.67	2.551	.57
9	50.76	2.170	.49
10	44.92	1.920	.43
11	41.21	1.762	.40
12	37.55	1.605	.36
13	35.39	1.513	.34
14	35.25	1.507	.34
15	34.84	1.489	.33
16	35.52	1.518	.34
17	37.86	1.619	.36
18	42.05	1.798	.40
19	47.91	2.048	.46
20	55.74	2.383	.54
21	63.57	2.718	.61
22	70.84	3.028	.68
23	74.66	3.192	.72
24	78.58	3.359	.76
SUM	846.34	36.178	
AVG			.34

TABLE 10

HEATING LOAD FOR THE AVERAGE HOME
Summer Season
Off-Peak
100% Oil Displacement

HOUR	KWH	% OF TOTAL SEASONAL KWH	AVERAGE KW
1	132.13	5.648	.86
2	136.69	5.843	.89
3	140.89	6.022	.92
4	143.03	6.114	.93
5	148.41	6.344	.97
6	142.57	6.094	.93
7	123.84	5.294	.81
8	42.24	1.806	.86
9	35.95	1.537	.73
10	29.99	1.282	.61
11	27.33	1.168	.56
12	24.98	1.068	.51
13	23.01	.984	.47
14	22.55	.964	.46
15	21.11	.902	.43
16	21.48	.918	.44
17	21.75	.930	.44
18	24.56	1.050	.50
19	29.33	1.254	.60
20	34.31	1.466	.70
21	38.04	1.626	.78
22	40.46	1.729	.83
23	43.46	1.858	.89
24	44.94	1.921	.92
SUM	1493.05	63.822	
AVG			.71
TOTAL SEASONAL KWH		2339.39	

TABLE 11

TOTAL ELECTRIC HEATING LOAD FOR THE AVERAGE HOME
100% OIL DISPLACEMENT

TOTAL KWH BY HOUR AND MONTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM
1	188.07	152.29	141.89	83.03	49.10	.00	.0	.00	28.11	77.66	117.10	158.49	995.73
2	185.63	152.95	143.70	84.90	51.79	.00	.00	.00	29.54	78.63	117.36	159.78	1008.29
3	191.46	154.66	145.20	86.85	54.03	.00	.00	.00	30.87	79.13	119.63	161.24	1023.08
4	191.80	153.87	147.51	87.97	55.06	.00	.00	.00	32.07	80.86	120.33	163.89	1033.35
5	191.60	154.96	148.45	88.95	59.46	.00	.00	.00	33.45	81.56	120.31	165.32	1044.06
6	192.06	155.24	147.45	88.63	53.94	.00	.00	.00	33.27	82.80	121.70	168.07	1043.16
7	192.24	156.64	148.13	84.44	39.40	.00	.0	.00	30.12	81.36	121.94	165.98	1020.19
8	191.15	154.92	141.51	73.57	28.35	.00	.00	.00	23.82	72.75	120.07	165.54	971.69
9	188.49	150.52	135.02	64.13	22.58	.00	.00	.00	18.81	63.89	111.02	163.27	917.73
10	184.73	145.86	124.86	57.44	17.47	.00	.00	.00	14.49	54.46	102.59	159.15	860.74
11	178.99	139.14	118.48	53.58	14.97	.00	.0	.00	11.89	47.59	96.40	153.75	814.78
12	174.17	133.17	113.10	49.95	12.58	.00	.00	.00	10.96	44.78	93.61	149.68	782.20
13	171.74	129.74	109.23	46.78	11.62	.00	.00	.00	9.87	40.74	92.93	146.11	758.71
14	170.92	128.83	107.73	45.21	12.60	.00	.00	.00	9.71	38.74	93.65	144.74	751.33
15	170.56	127.95	106.11	44.24	11.70	.00	.00	.00	9.06	40.60	94.70	144.26	748.99
16	172.02	129.46	105.88	44.46	12.54	.00	.00	.00	10.20	43.01	97.49	146.95	762.00
17	174.79	131.91	109.20	45.91	13.71	.00	.0	.00	11.06	46.48	101.72	151.39	790.19
18	178.39	137.35	114.97	50.33	16.28	.00	.00	.00	14.41	57.99	106.40	153.57	829.69
19	179.57	141.18	119.51	56.75	20.49	.00	.00	.00	18.35	62.59	109.27	153.69	861.40
20	181.84	143.57	125.37	63.74	26.31	.00	.00	.00	22.79	67.33	111.98	155.38	898.30
21	182.89	145.76	128.92	68.40	33.21	.00	.00	.00	24.32	69.09	113.73	156.75	923.09
22	183.13	147.41	132.63	72.13	39.17	.00	.00	.00	27.79	72.46	114.33	157.47	946.52
23	184.29	147.65	134.76	75.44	42.69	.00	.00	.00	28.05	74.21	115.68	158.63	961.59
24	186.48	149.28	137.69	77.85	45.67	.00	.0	.00	28.75	75.80	117.52	158.71	977.74
SUM	4390.98	3463.20	3067.31	1594.67	744.72	.00	.00	.00	511.76	1536.51	2631.46	3761.94	21724.56

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TABLE 12

AVERAGE DAILY ELECTRIC HEATING LOAD FOR THE AVERAGE HOME
100% OIL DISPLACEMENT

AVERAGE KWH BY HOUR AND MONTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG
1	6.07	5.44	4.58	2.77	1.58	.00	.00	.00	.94	2.51	3.90	5.11	2.74
2	6.12	5.46	4.64	2.85	1.67	.00	.00	.00	.98	2.54	3.91	5.15	2.78
3	6.18	5.52	4.68	2.90	1.74	.00	.00	.00	1.03	2.55	3.99	5.20	2.82
4	6.19	5.50	4.76	2.93	1.78	.00	.00	.00	1.07	2.61	4.01	5.29	2.84
5	6.18	5.53	4.79	2.96	1.92	.00	.00	.00	1.12	2.63	4.01	5.33	2.87
6	6.20	5.54	4.76	2.95	1.74	.00	.00	.00	1.11	2.67	4.06	5.42	2.87
7	6.20	5.59	4.78	2.81	1.27	.00	.00	.00	1.00	2.62	4.06	5.35	2.81
8	6.17	5.53	4.56	2.45	.91	.00	.00	.00	.79	2.35	4.00	5.34	2.68
9	6.09	5.38	4.36	2.14	.73	.00	.00	.00	.63	2.06	3.78	5.27	2.53
10	5.96	5.20	4.13	1.91	.56	.00	.00	.00	.48	1.76	3.42	5.19	2.37
11	5.77	4.97	3.82	1.79	.48	.00	.00	.00	.40	1.54	3.21	4.96	2.24
12	5.62	4.76	3.65	1.67	.41	.00	.00	.00	.37	1.44	3.12	4.83	2.15
13	5.54	4.63	3.52	1.58	.37	.00	.00	.00	.33	1.31	3.10	4.71	2.09
14	5.51	4.57	3.48	1.51	.41	.00	.00	.00	.32	1.25	3.12	4.67	2.07
15	5.50	4.57	3.42	1.47	.38	.00	.00	.00	.30	1.31	3.16	4.65	2.06
16	5.55	4.62	3.42	1.48	.40	.00	.00	.00	.34	1.39	3.25	4.74	2.10
17	5.64	4.71	3.52	1.53	.44	.00	.00	.00	.37	1.63	3.39	4.88	2.18
18	5.75	4.91	3.71	1.66	.53	.00	.00	.00	.48	1.87	3.55	4.95	2.29
19	5.79	5.04	3.86	1.89	.66	.00	.00	.00	.61	2.02	3.64	4.96	2.37
20	5.87	5.13	4.04	2.17	.85	.00	.00	.00	.76	2.17	3.73	5.01	2.47
21	5.90	5.21	4.16	2.28	1.07	.00	.00	.00	.81	2.23	3.79	5.06	2.54
22	5.91	5.26	4.28	2.49	1.26	.00	.00	.00	.93	2.34	3.81	5.08	2.61
23	5.94	5.27	4.35	2.51	1.38	.00	.00	.00	.93	2.39	3.86	5.12	2.65
24	6.00	5.33	4.44	2.59	1.47	.00	.00	.00	.96	2.45	3.92	5.13	2.69
AV.	5.90	5.15	4.15	2.21	1.00	.00	.00	.00	.71	2.07	3.65	5.06	2.49

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